REMOVAL OF ACID BLUE 25 DYE BY USING DRIED WATER HYACINTH FROM AQUEOUS SOLUTION

A thesis submitted in the the fulfillment
of the requirements for the award of the degree of
Bachelor of Chemical Engineering

Faculty of Chemical Engineering & Natural Resources
Universiti Malaysia Pahang

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ABSTRACT

Water hyacinth (*Eichhornia crassipes*) is a free floating aquatic weeds that robustness in its growth used as an adsorbent to remove Acid Blue 25 dye from aqueous solution. The parameters studied include the adsorbent dosage, initial dye concentration, pH, and also contact time in a batch adsorption process at room temperature 21°C. The results shows the optimum conditions for each parameter studied, adsorbent dosage at 0.60 g, initial concentration 400 mg/L, pH 2 and 100 minutes contact time. The samples after the dye uptake were analyzed by using UV-Vis spectrophotometer. Furthermore, before and after the experiments, FTIR analyses were studied to know the functional groups of the water hyacinth. In addition, the equilibrium data fitted well pseudo-second order kinetics, Langmuir and Freundlich isotherm. The maximum sorption capacities for Langmuir equation were 83.33 mg/g whereas the amount of n for Freundlich is favourable. While for pseudo-second-order kinetics, it has a low error for equilibrium sorption capacity for experimental and calculated values. This study is favourable and economically feasible for the removal of Acid Blue 25.

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ABSTRAK

Keladi bunting merupakan gulma air yang mengambang yang digunakan sebagai adsorben untuk menyingkirkan pewarna Asid Biru 25 dari akuas larutan. Parameter yang dipelajari meliputi dos adsorben, kepekatan pewarna awal, pH, dan juga masa tindakbalas dalam proses jerapan batch pada suhu bilik 21º C. Keputusan menunjukkan keadaan optimum untuk setiap parameter yang diteliti, dos adsorben pada 0.60 g, kepekatan awal 400 mg / L, pH 2 dan masa tindakbalas 100 minit. Kesemua kepekatan akhir larutan dianalisa menggunakan UV-Vis Spectrophotometer. Selanjutnya, sebelum dan selepas percubaan, analisis FTIR dipelajari untuk mengetahui kumpulan-kumpulan berfungsi keladi bunting. Selain itu, data keseimbangan menepati kinetika orde pseudo-kedua Langmuir dan Freundlich isotherm. Kapasiti jerapan maksimum untuk persamaan Langmuir adalah 83.33 mg/g manakala untuk Freundlich isotherm nilai *n* sesuai. Sedangkan untuk kinetik pseudo-orde kedua, ia memiliki kesilapan rendah untuk kapasiti keseimbangan sorpsi untuk nilai eksperimental dan dikira. Penelitian ini menguntungkan dan layak secara ekonomi untuk menghilangkan Asid Biru 25.

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LIST OF ABBREVIATIONS

AB 25	=	Acid Blue 25
NH_2	=	Amine
OH	=	Hydroxide
NH_3	=	Ammonia
CAS	=	Ethylenediamine modified starch
COD	=	Chemical oxygen demand

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REMOVAL OF ACID BLUE 25 DYES FROM AQUEOUS SOLUTION BY USING DRIED WATER HYACINTH

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Abstract

Water hyacinth (*Eichhornia crassipes*) is a free floating aquatic weeds that robustness in its growth used as an adsorbent to remove Acid Blue 25 dyes from aqueous solution. The parameters studied include the adsorbent dosage, initial dye concentration, pH, and also contact time in a batch adsorption process at room temperature 21ºC. The results shows the optimum conditions for each parameter studied, adsorbent dosage at 0.60 g, initial concentration 400 mg/L, pH 2 and 100 minutes contact time. The samples after the dye uptake were analyzed by using UV-Vis spectrophotometer. Furthermore, before and after the experiments, FTIR analyses were studied to know the functional groups of the water hyacinth. In addition, the equilibrium data fitted well pseudo-second order kinetics, Langmuir and Freundlich isotherm. The maximum sorption capacities for Langmuir equation were 83.33 mg/g whereas the amount of *n* for Freundlich is favourable. While for pseudo-second-order kinetics, it has a low error for equilibrium sorption capacity for experimental and calculated values. This study is favourable and economically feasible for the removal of Acid Blue 25.

Keywords: Dried water hyacinth, Acid Blue 25, Adsorbent, Adsorption isotherm, Pseudo-second-order kinetics

1.0 Introduction

Nowadays, in the world of globalization, there are a lot of potential industrial sector growths, especially in Malaysia. In Malaysia textile industry, 'Batik' is well known material. The big consumers of dyes are textile, dyeing, paper and pulp, tannery and paint industries, and hence the effluents of these industries as well as those from plants manufacturing dyes tend to contain dyes in sufficient quantities (Gupta *et al*., 2009). Approximately a half of all known dyes are azo dyes, making them the largest group of synthetic colourants (K.Selvam *et al*., 2002). W.A.Sadik, (2007) reported that azo dyes represent about 60-70% of the dye used. Moreover, azo dyes effluent that goes to the water stream will be a significant threat to environmental health and people. There are many types of azo dyes, such as Acid Blue 25, Acid Orange 52, Acid Red 14, Acid Brown dye, Acid Red 1 and many more. Acid blue 25 is a common dye shown in wastewater from the textiles industries.

Various physical, chemical, and biological methods, namely, adsorption, biosorption, coagulation, precipitation, membrane filtration, solvent extraction, chemical oxidation and photochemical degradation have been used for the treatment of dye containing wastewater (Necip *et al*., 2009). As reported by Bansal and Goyal, (2005), adsorption is one of the processes, which besides being widely used for dye removal also has wide applicability in wastewater treatment. Various adsorbent wastes are used in colour removal processes such as activated carbon, chitosan and natural wastes (e.g. cellulose derivatives, wood pulp, peat, feathers, hair, sawdust) (McKay G, 1996). Water hyacinth (*Eichhornia crassipes*,) is useful as a medium or adsorbent to remove nutrients and heavy metals that contain toxic which could play a role against environmental pollution. While dried water hyacinth is commonly used instead of aquatic water hyacinth. It is because, dried water hyacinth did not affect the spreading of dengue fever to the residents near by.

In this study, the adsorption of Acid Blue 25 using the dried water hyacinth, *Eichhornia crassipes* was investigated. As they are readily available in great abundance water hyacinth roots could represent an economically source of adsorbent for acid dyes.

2. Materials and methods

2.1 Adsorbent

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The water hyacinth is collected from the local Gambang Lake, Pahang. They were washing thoroughly by using tap water for several times in order to removes dirt on the aerial and leafs. It is chopped into small pieces to ease of drying. The water hyacinth then dried in the oven at 60ºC, 24 -72 hour until the moisture content is remained the same. The adsorbent is then blended by using dry blender. Next, the adsorbent were sieved by using sieve shaker for about 5 minutes. Only the adsorbent with size 45 µm (C.Namasivayam *et al*., 1996) is used for overall experiments. Moreover, the adsorbent stored in the plastics tupperware in order to remained the moisture content.

2.2 Adsorbate

Acid Blue 25 dye is anionic dye with the molecular formula $C_{20}H_{13}N_2NaO_5S$ which commonly used in textiles, paper and also detergent industries purchased from Sigma Aldrich. The maximum adsorption wavelength of Acid Blue 25 is 600 nm. The structures of Acid Blue 25 were shown in the figure 1. The Acid Blue 25 were used directly without any purification or pre-treatment process or procedures and diluted by using distilled water. The stock solution of 1000 mg/L was prepared by dissolving AB25 in 1000 mL distilled water.

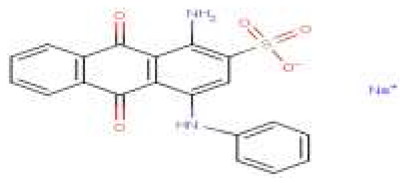

Figure 1: Molecular structure of Acid Blue 25

2.3 Fourier Transform Infrared Study

Fourier Transform Infra-Red (FTIR) analysis was carried out on the dried water hyacinth to determine its functional groups, by using FTIR Spectrometer (FTIR, Thermo Nicolet), with spectra were set from 4000 to 400 cm^{-1}.

2.4 Batch adsorption studies

The experiments were proceed in a Orbital Shaker at 200 rpm and at room temperature, 21°C using 250 mL conical flasks containing 50 mL different initial concentrations and pH values of AB25 solution. The initial pH values of the solutions were adjusted with 0.1M Sodium Hydroxide, NaOH or 0.1M Hydrochloric Acid, HCL before each experiment. The pH was measured by using a pH meter (Metrohm). A number of doses of dried water hyacinth were added to each flask, and then the flasks were sealed up with parafilm or aluminium foil to prevent any spilling that could change the volume of solution during the experiments. After shaking the flasks for a period of time intervals, the aqueous samples were taken and centrifuge using (Eppendorf Centrifuge 5810R) at 5000 rpm, 21°C for about 30 minutes. After centrifuge, the supernatant were collected by using disposable pipet and transfer into the sample bottles before analyzing the OD at the UV-Vis Spectrophotometer (Hitachi, Model U - 1800) at its maximum wavelength, 600 nm. The kinetic data of adsorbed amount of dye at time t, q_t (in mg/g of adsorbent), were obtained by the mass balance:

$$q_t = \frac{(C_o - C_t)V}{W}$$

where C_o is the initial concentration of AB25 (mg/L) and C_t is the concentration of Acid Blue 25 at any time (mg/L), V is the volume of solution in L and W is the mass of adsorbent used in g.

3. Results and discussion

3.1 FTIR analysis

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Figure 2(a) shows the adsorption peak of several compounds that found on the dried water hyacinth. The adsorption site indicated maximum wave number at 3200 cm^{-1} to 3400 cm^{-1}, representing stretching of –OH groups. Furthermore absorption peaks around 3300 cm^{-1} to 3600 cm^{-1} represent the presence of NH_2 which is the amine group (P.N palanisamy *et al*., 2009). The stretching at 1618 cm^{-1} is represents C - C bending. Whereas for the C – H bending approximately at 2900 cm^{-1} and for C –O is around 1200 cm^{-1}. However after running the experiments at optimum conditions for all the parameters, we can see the FTIR analysis on Figure 2(b). The peak is became lowered and some parts of it is becoming straight line. It is convinced that the adsorption process between dried water hyacinth and Acid Blue 25 occurs.

(a) (b)

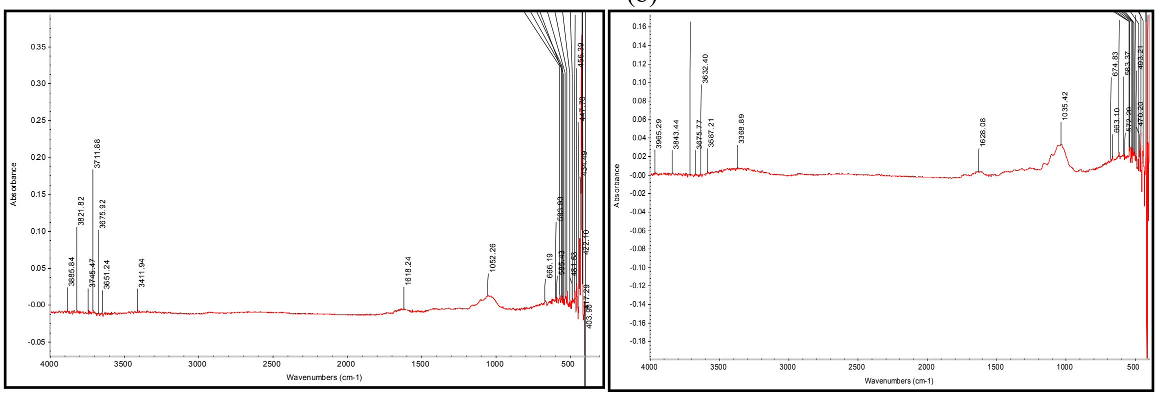

Figure 2: The FTIR analysis of dried water hyacinth (a) before and (b) after dye uptake

3.2 Effect of adsorbent dosage

The study of adsorbent dosage effect on Acid Blue 25 dye, has been conducted by using dried water hyacinth dosage from range (0.1 - 1.0g) while other parameters remain constant (C_o = 300 mg/L, pH = 3.0, contact time = 60 minutes, speed = 200 rpm). Results are as shown in figure 3 (a). It shows that the uptake of the Acid Blue 25 increased with the increase amount of adsorbent dosage. The adsorption percentage remains constant after 93% at dosage of 0.60 g even after increasing the dosage of the adsorbent. Whereas for the the amounts of dye adsorbed per unit mass remain decreased from 81.75 to 18.68 mg/g as shown in figure 3 (b). The experiment is repeated by using different initial concentration which is 400mg/L and 500mg/L while the other parameter is remains constant. This experiment is performed to see the trend of percentage removal of dye and similar results and trends as in the earlier experiment were obtain as shown in figure 3 (a) were dosage is 0.60g. It shows that, the optimum adsorbent dosage for removal of Acid Blue 25 is at 0.60 g of dried water hyacinth. It is similar trend shown by M.M.El. Zawahry *et al*., (2004) with relating low error between this experiments and his journal on removal of azo and anthraquinone dyes from aqueous solutions by *Eichhornia crassipes*.

The percentage removal of Acid Blue 25 increased with the increase in adsorbent dosage. It is might be due to increased adsorbent surface area and availability of more adsorption sites resulting from the increase of adsorbent dosage. This result is similar with the results from the Low *et al*., (1995) and M. Arami *et al*., (2008) for removal of the methylene blue by using dried water hyacinth. However, the decreasing of adsorption dye per unit mass with increasing of adsorbent dosage is because of there is reduction on effective surface area or in simple words it is already saturated. Similar results by H. Aydin *et al*., (2006) on adsorption of acid dyes by shells of bittim M. M. El Zawahry *et al*., (2004) on removal of azo and anthraquinone dyes by water hyacinth.

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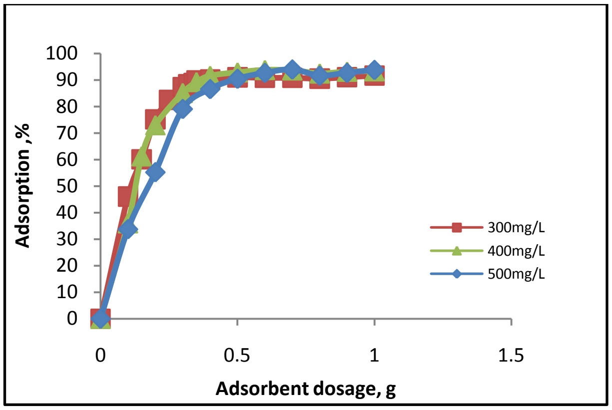
(a)

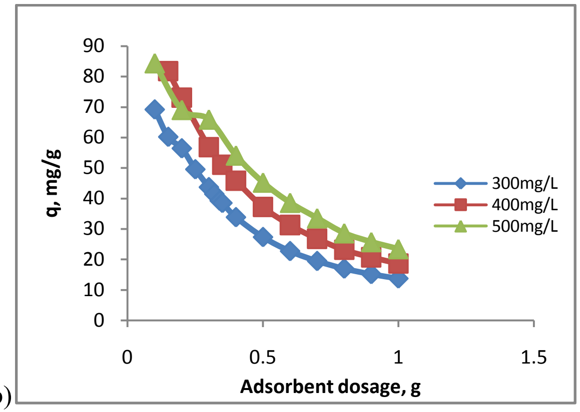
(b)

Figure 3: The effect of adsorbent dosage for the removal of Acid Blue 25. Time = 60 min, speed = 200 rpm, pH = 3.0, C_o = 300 – 500 mg/L, dosage = 0.1 – 1.0g, at room temperature. (a) Percentage removal and (b) amount of dye sorbed

3.3 Effect of initial concentration

The study of initial concentration effect on Acid Blue 25 dye uptake can be observed in Figure 4. Experiment is performed by varying the value of initial concentration from the range of 80 mg/L to 500 mg/L and fixed the value for other parameters (dosage = 0.60g, speed = 200 rpm, pH = 3.0, time = 60 minutes). In figure 4 (a) indicates that as the initial concentration increase, the percentage removal increased until it reaches equilibrium at 400 mg/L and after that the dye uptake started to remain constant. Besides, the results for amount of dye sorbed per unit mass is continually increase by increasing of concentration of Acid Blue 25 dye as shown in figure 4 (b). Similar with the first parameter, experiment is repeated by using different adsorbent dosage 0.30 g and 0.80 g while remained other parameter remain constant. The trend for repeated trials are observed and the same trend of graph has been obtained as the dosage of 0.60 g. From the graph, optimum initial concentration is at 400 mg/L where the percentage of adsorption is 92% of Acid Blue 25 dye.

From Figure 4 (a) and (b), we can see that the uptake of dye increases with increase in the initial dye concentration. This is might be because of the initial dye concentration provides necessary driving force to overcome the resistance to the mass transfer between the aqueous and solid phase. The increase in dye concentration diminishes the resistance and makes more contact between dye and adsorbent. Availability of dye molecules in the vicinity of adsorbent also increases while increasing the concentration, which results in high uptake of dye at higher concentration. Similar finding is also reported by Palanysamy *et al*., (2009). However, for the adsorbent dosage 0.30 g, the amount of percentage adsorbed is decreasing after 300mg/L. This is because of when the adsorption site of the adsorbent is already saturated, backwash process will happen on the adsorbent surface. There could not uptake the amount of dye into the adsorption site. It is due to smaller mass transfer occurring since all the adsorption sites has been fully occupied.

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(a) (b)

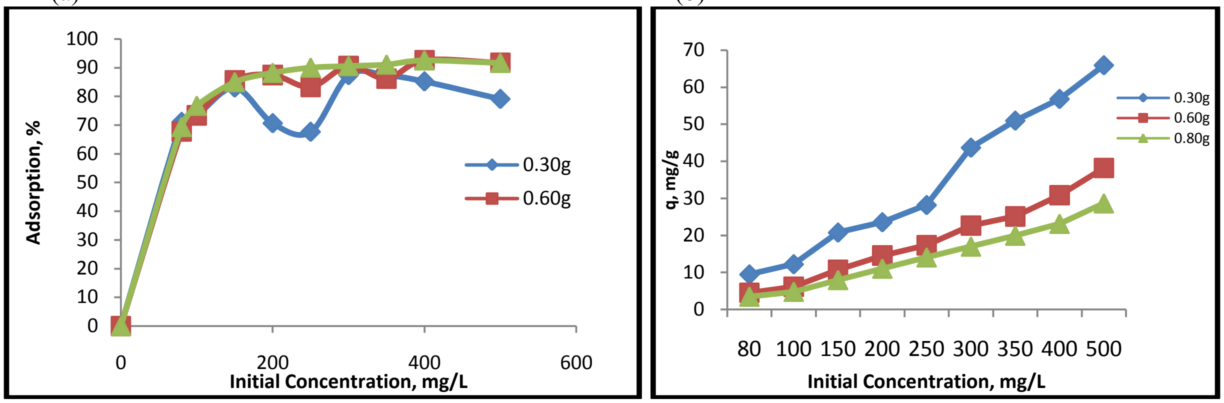

Figure 4: The effect of initial concentration for the removal of Acid Blue 25. Time = 60 min, speed = 200 rpm, pH = 3.0, C_o = 80 – 500 mg/L, dosage = 0.30 – 0.80g, at room temperature. (a) Percentage removal (b) amount of dye sorbed

3.4 Effect of pH

The pH of the aqueous solution is an important controlling parameter in the dyes sorption processes. The influence of pH on the adsorption capacity was observed over a pH range of 1 – 11 while other parameters remain constant at optimum condition for the first and second parameter which is at 0.60 g adsorbent dosage and 400 mg/L of initial concentration and speed = 200 rpm, contact time = 60 minutes and at room temperature. As can be seen at figure 5 (a) the maximum capacity for initial concentration 400 mg/L achieves at pH value of 2.0 and the optimum uptake of Acid Blue 25 dye is 92%. Whereas, for the amount of dye per unit mass is decreasing with the increasing of pH and can be seen in the Figure 5(b). Similar with other parameter above, in this parameter, method is repeated in different initial concentration in order to see the trend of the optimum pH of dried water hyacinth on the Acid Blue 25 dye. Optimum pH for different concentration is remains the same which is at pH 2.0.

With the increase of pH value, the adsorption capacity for each initial concentrations decreases. Acid Blue 25 is anionic in nature and increased adsorption in an acidic medium. Whereas, it is increased desorption in an alkaline medium showed that these dyes were held by the adsorbent, most probably by ion exchange. A similar trend was observed for desorption of congo red and procion orange by waste orange peel (Namasivayam *et al.,* 1996). At lower pH, there are excessive in H^+ ion while Acid Blue 25 is anionic, so adsorption rate towards the dried water hyacinth is higher. This is because, the molecules of dye anions bind at the sorption sites at the surface of sorbent. . Thus, enhance the capability of the binding activity between dye anions and sorbent surface through electrostatic forces of attraction. Meanwhile, the removal of dye is low at high pH due to the excess of hydroxide ions, OH^-, competing with the molecules of dye anions to bind at the sorption sites at the surface of sorbent. This statement is supported by the FTIR analysis that shows lowered absorbance after the dye uptakes from 3411.94 to 3368.89.

(a) (b)

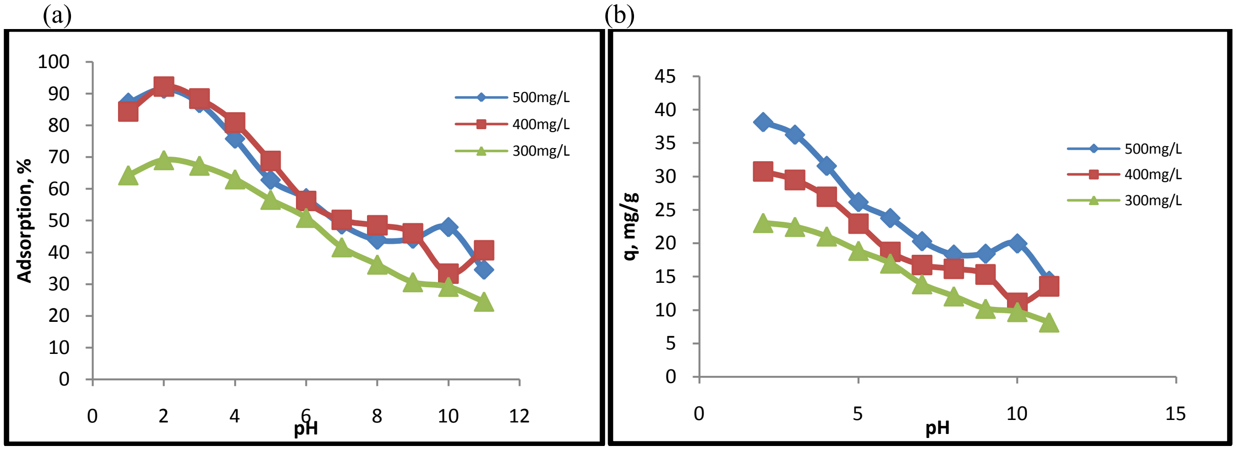

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Figure 5: The effect of pH for the removal of AB25. Time = 60 min, speed = 200 rpm, pH = 1.0 – 11.0, C_o = 300 – 500 mg/L, dosage = 0.60 g, at room temperature. (a) Percentage removal and (b) Amount of dye sorbed

3.5 Effect of contact time

Effect of contact time is another important parameter that influences the adsorption rate of Acid Blue 25 dye in the dried water hyacinth. This parameter is identified by using optimum condition of another 3 parameter which at 0.60 g adsorbent dosage, 400 mg/L initial concentration, and pH 2 while the other parameter is remain constant at 200 rpm speeds and room temperature. The contact time range for this experiment is within 10 – 120 minutes. Figure 6 shows the result of this trial where (a) indicate the percentage dye removal and (b) is the sorption equilibrium per mass. It can be explained clearly that the dye uptake increase with the increasing of time contact between the dye and adsorbent until it reached equilibrium at 100 minutes. Further experiment on time contact results in constant value of removal which is at 92%. Another two trials were repeated by using different initial concentration which is 300 mg/L and also 500 mg/L. The outcome from the other trials is similar with the first trials.

The rate of adsorption is higher in the beginning, where at the first 50 minutes of interactions, which due to large available surface area of the dried water hyacinth. After that, the capacity of the adsorbent fully occupied which is at equilibrium state or it is become saturated, the rate of uptake is getting slower from the exterior to the interior sites of the adsorbent particles similar trend found in the B.H.Hameed *et al.*, (2008). If this experiments is proceed, desorption process will take over than the adsorption. This is due the interactions between dried water hyacinth and dyes is relating slow.

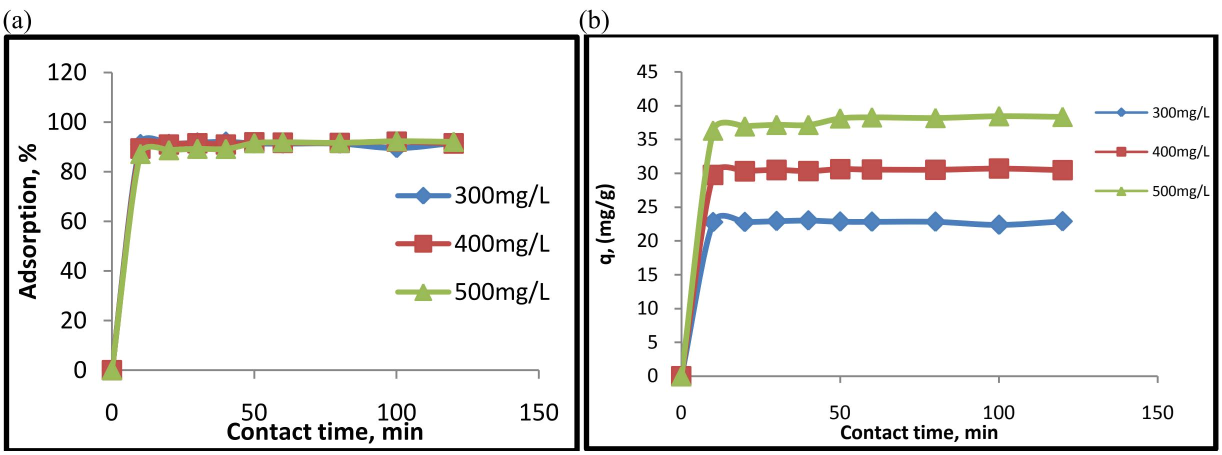

Figure 6: The effect of contact time for the removal of Acid Blue 25. Time = 10 - 120 min, speed = 200 rpm, pH = 2.0, C_o = 300 – 500 mg/L, dosage = 0.60 g, at room temperature. (a) Percentage removal and (b) Amount of dye sorbed

3.6 Kinetics of the adsorption process

Pseudo – second-order illustrates the adsorption kinetic of Acid Blue 25. It is to indicate whether it is agreed very well to the experimental data or not. The second-order kinetic model is express as:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \qquad (4.10)$$

where k_2 is the pseudo-second-order rate constant (g/mg.min); q_e the quantity of dye adsorbed at equilibrium (mg/g); q_t the quantity of dye adsorbed at time t (mg/g) and t is the time (min).

Figure 7 shows the removal rate of Acid Blue 25 was very fast during the initial stages of the adsorption processes, especially for initial dye concentration of 400mg/L. However, the adsorption equilibrium was reached at 100 min for all three concentrations tested. Furthermore, the data fitted well the second order kinetic model (R^2 > 0.999) for every line. Besides, the calculated q_e values agree very well with the experimental data listed in table 1.

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Similar kinetic results were reported in the removal of the diazo dye reactive black 5 by sunflower seed shells and mandarin peelings by J.F.Osma *et al*., (2007).

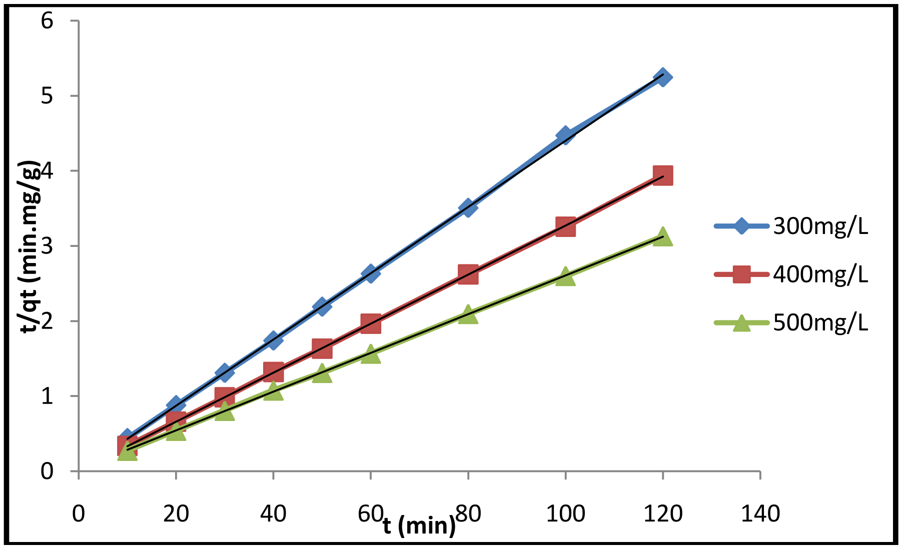

Figure 7: Pseudo-second- order adsorption kitetics of Acid Blue 25 at pH 2 and different initial AB25 concentrations.

Table 1: Pseudo-second-order adsorption rate constants and calculated and experimental q_e values for different initial concentration of Acid Blue 25 at pH 2.

Acid Blue 25 (mg/L)	K_2 (g/mg.min)	q_e calc (mg/g)	q_e exp (mg/g)	R^2
300	0.1936	22.42	22.72	0.999
400	0.2048	30.25	31.25	1
500	0.0025	60.37	40	0.999

3.7 Adsorption Isotherms

3.7.1 Langmuir isotherm

The Langmuir isotherm was used for its ability to explain the experimental results. The derivation of the Langmuir isotherm is based on the assumption of ideal monolayer adsorption on a homogenous surface. Once a dye molecule occupies a site, no further adsorption can take place at that site. The Langmuir adsorption isotherm has been successfully used to explain the dye removal by using hazelnut shells and wood sawdust (F.Ferrero., 2007). The Langmuir isotherm was expressed as:

$$q_e = \frac{K_L q_m C_e}{1+ K_L C_e}$$

where q_e is the equilibrium adsorption capacity (mg/g), q_m the maximum amount of dye adsorbed (mg/g) corresponding to monolayer coverage, K_L the Langmuir constant (L/mg) and C_e is the equilibrium concentration of dye in bulk solution (mg/L).

Figure 8 fitted the Langmuir equation, accordingly to the data which also confirmed by the high value of R^2 which is 0.876. This verifies that the sorption of Acid Blue 25 on dried water hyacinth. Table.2 indicates that the

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computed maximum amount of B25 adsorbed (q_m) of which is 83.33 mg/g. this value was similar with the value found by J.F.Osma *et al*., (2007) in the removal of reactive black 5.

Furthermore, in order to see whether this experimental is favourable, the dimensionless separation factor R_L is identified. R_L can be expressed as:

$$R_L = \frac{1}{1 + K_L C_o}$$

where C_o is the initial concentration of Acid Blue 25. The value of R_L indicates the shape of the isotherm to be either unfavourable ($R_L > 1$), linear ($R_L = 1$), favourable ($0 < R_L < 1$) or irreversible ($R_L = 0$). The R_L values between 0 and 1 indicate favourable adsorption. As shown in figure 9, the value of R_L is between 0.001998 - 0.004989. It is shows that the adsorption process is favourable.

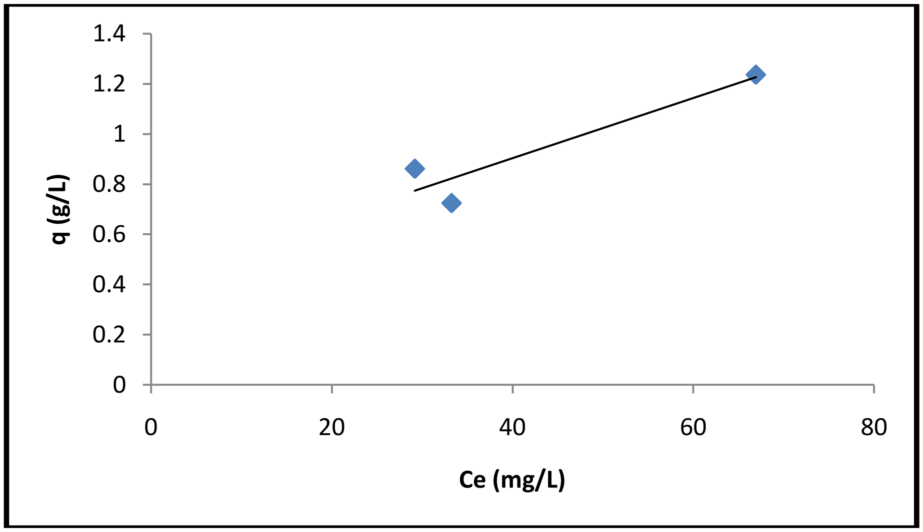

Figure 8: Langmuir isotherm plots for Acid Blue 25 sorption on dried water hyacinth

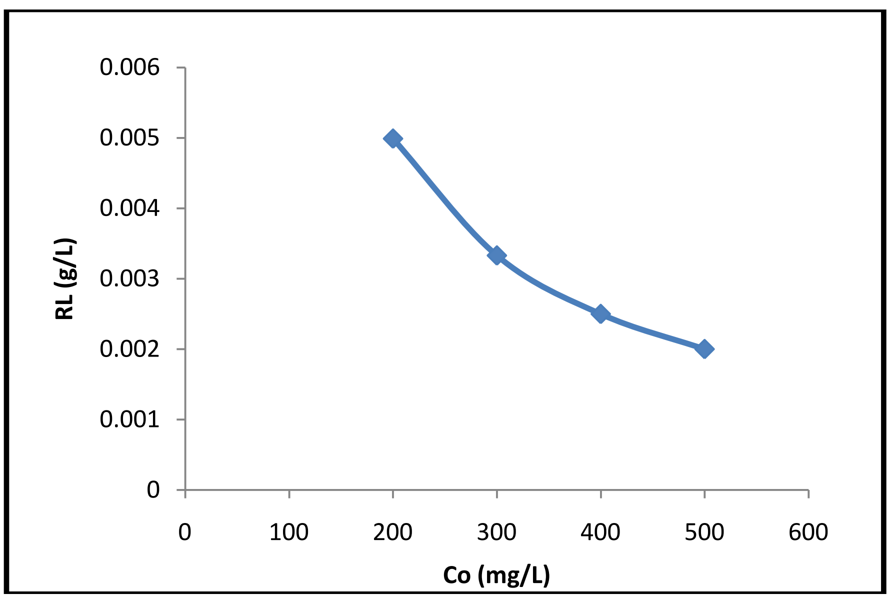

Figure 9: Separation factor for Acid Blue 25 sorption on dried water hyacinth.

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Table 2: Langmuir isotherm constant for Acid Blue 25 sorption on dried water hyacinth at adsorbent dosage 0.40g (initial concentration: 300, 400, 500 mg/L)

C_e (mg/L)	q_e (mg/g)	C_e/q_e	q_m (mg/g)	K_L	R^2
29.17021	33.85372	0.861654	83.33	0.028235	0.876
33.23404	45.84574	0.72491			
66.91489	54.13564	1.23606			

3.6.2 Freundlich isotherm

The freundlich isotherm is an empirical model that considers heterogeneous adsorptive energies on the adsorbent surface. It is express by the following equation:

$$q_e = K_F C_e^{1/n} \qquad (4.40)$$

where q_e (mg g^{-1}) is the amount of dye adsorbed at equilibrium, Ce (mg L^{-1}) the dye concentration at equilibrium and K_F and n are the Freundlich constants for the system, which are indicators of adsorption capacity and intensity, respectively.

To determine the constants K_F and n the linear form of the equation is used:

$$\ln q_e = \ln K_F + \frac{1}{n}\ln C_e$$

The plot of ln q_e versus ln Ce (Figure 10) is employed to generate the intercept K_F and the slope 1/n. The values of K_F, *n*, the experimental and the calculated q_e (mg g^{-1}) values and the linear regression correlation (R^2) for Freundlich are given in the table 4.3. From the figure 4.8, The Freundlich constant, K_F increased with increase in temperature. The value of n shown in table 4.3 is greater than 1.0 indicating the adsorption Acid Blue 25 on to dried water hyacinth is favourable. There is no remarkable difference in the correlation coefficient between Freundlich and Langmuir models. The adsorption isotherm data fits reasonably well for both Langmuir and Freundlich models.

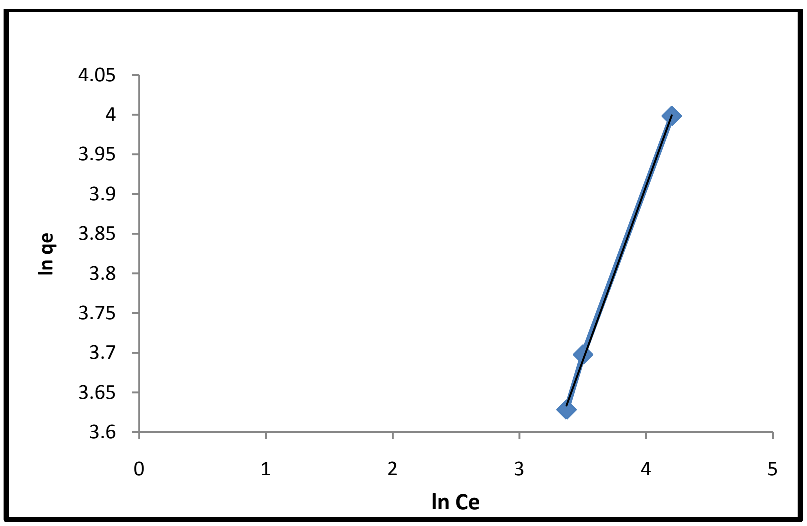

Figure 10: Freundlich isotherm plots for Acid Blue 25 sorption on dried water hyacinth

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Table 3: Freundlich isotherm constant for Acid Blue 25 sorption on dried water hyacinth at adsorbent dosage 0.40g (initial concentration: 300, 400, 500 mg/L)

Acid Blue 25 (mg/L)	q_e calc (mg/g)	q_e exp (mg/g)	K_F	n	R^2
300	37.79522	37.63692	8.5677	2.2727	0.999
400	40.02765	40.34195			
500	54.46197	54.4919			

4.0 Conclusion

All the data and analysis done in this study is fulfilling the objectives of the study which is to study the removal of Acid Blue 25 from aqueous solution. The removal of Acid Blue 25 by using dried water hyacinth is enhanced by manipulating the initial concentration of Acid Blue 25, such as adsorbent dosage, pH and also contact time at the optimum conditions. The optimum conditions for all the parameters are 400 mg/L of initial concentration, 0.60 g dosage, pH 2 and also 100 minutes of time contact. In order to verify the experimental data on the adsorption process, pseudo-second-order analysi, Langmuir and Freundlich isotherm were performed. Data that analyze by using pseudo-second-order is used for the comparison between q_e calculated and q_e experimental which is at high value of R^2 (0.999). Furthermore, the calculated q_e values agree very well with the experimental data with low value of error. So it is shows that, this study is verified using pseudo-second-order for the kinetics of the adsorption process. Besides, for the Langmuir isotherm, it is used to explain the ability of dried water hyacinth in this experiment. For the first analysis, the value of q_m, the maximum amount of dye adsorbed is 83.33 mg/g and the value of K_L, the Langmuir constant is 0.028235 L/mg. Whereas the value of R^2 is 0.876. Moreover, for second analysis on separation factor or R_L is on the range between 0.001998 - 0.004989 which is shows that the adsorption process is favourable. Freundlich isotherm is commonly just the same as the Langmuir isotherm. As for the freundlich isotherm, is an empirical model that considers heterogeneous adsorptive energies on the adsorbent surface. In these experiments is favourable since the value of n is more than 1. So, this study is verified for pseudo-second-order kinetic analysis and also Langmuir and freundlich isotherm.

4.1 Recommendation

In this study, experiments were performing in the batch reaction process. In order to scale up this experiment, it should be continued by running it in an adsorption column. Since, nowadays concern of the environment is relating high among the society. So, by performing in industrial scale experiments, it will help much on the environmental problems around the world.

Furthermore, during the experiment, there is no analysis on the Scanning Electrostatic Microscopic (SEM). By doing these analysis, the structure of dried water hyacinth on both before and after dye uptake can be observed. Moreover, by doing SEM analysis, it will be identified whether the dried water hyacinth is a good adsorbent or not.

Besides, for optimizing the experiment to solve the real world's environmental problems, these experiments can be performed by using the wastewater that comes from the industries such as textiles industries. Since the AB25 is commonly used in textiles industries.

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APPENDICES A

EXPERIMENTAL PROCESS AND EQUIPMENTS USED

Figure A1: Collecting the water hyacinth at Gambang Lake, Pahang

Figure A2: Washing the aerial and leaf by using tap water

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Figure A3: After washing air dried before drying on the oven

Figure A4: Water hyacinth before and after drying in the oven over 24-72 hours

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